A Research Note

Stabilization of Red Beet Pigments with Isoascorbic Acid

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ABSTRACT

Isoascorbic acid was investigated as a stabilizer for red beet pigments. Sterilized samples of red beet juice containing 0.05–1.0% isoascorbic acid, with the pH adjusted to 3, 5, or 7, were stored under artificial light or in darkness at 25°C or at 5°C. The best pigment preservation was obtained with 0.1% added isoascorbic acid. After 30 days storage at 25°C, samples at pH 5 containing 0.1% isoascorbic acid retained 52% (under light) and 65% (in darkness) of the red beet pigments, whereas the controls faded to yellow within 6 days under the same conditions.

INTRODUCTION

RECENT TRENDS in consumer concern over the safety of food additives and new evidence that some artificial colorants may be hazardous to human health (Anon., 1978) have evoked increased interest in natural colorants. Among edible plants, the red beet (*Beta vulgaris*) is a potential source of useful water-soluble pigments, the betalaines (Pasch et al., 1975). However, the poor stability of this colorant represents a major obstacle to its application in food products (von Elbe et al., 1974) or soft drinks (Philip, 1978). To overcome this problem, various chemical additives have been investigated as stabilizers for beet pigments. Some of these additives, such as EDTA (Ethylenediaminetetraacetic acid), improve betanine stability (Savolainen and Kuuse, 1978). However, major discrepancies exist in the reported results concerning the use of ascorbic acid to stabilize beet pigments (Muschiolic and Schmandke, 1978; Pasch and von Elbe, 1979). The purpose of this investigation was to evaluate ascorbic acid and its isomer, isoascorbic acid, as stabilizers of betalaines under various conditions of temperature, pH, and light.

EXPERIMENTAL

AN AQUEOUS SOLUTION of 0.3% beet juice powder, obtained by a procedure previously described (Bilyk, 1979), was boiled for 3 min to inactivate enzymes which could degrade betacyanine during storage. The heated solution was immediately cooled to room temperature. After the addition of ascorbic or isoascorbic acid, the samples were adjusted with N/10 HCl or N/10 NaOH to either pH 3, 5, or 7 and were sterilized by filtration through disposable Falcon 0.22 micron membrane filters under vacuum. A 15 ml portion of the above pigment solution was pipetted aseptically with sterile disposable plastic syringes (Plastipak Becton-Dickinson) into sterile test tubes (Vacutainer Becton-Dickinson). Samples were stored at 5°, 25°, 50°, and 75°C, vertically, in darkness or under constant fluorescent lighting (G.E. Deluxe Cool White Tube, 15 Watt, Model F15T8-CWX) at an intensity of 120–140 ft-c of illumination. Absorbance measurements were made against a distilled water blank at 537 nm with a Bausch and Lomb Spectronic 21 D-V Spectrophotometer and between 375 and 650 nm with a Bausch and Lomb Spectronic 505 Recording Spectrophotometer (Sapers and Hornstein, 1979). The absorbance at 537 nm is due primarily to betacyanines although betalaine degradation products may interfere to some extent. Measurements were made initially and at 5-day intervals during 30-days storage, except that samples held at 50° and 75°C were examined at hourly intervals for up to 6 hr. Samples containing isoascorbic or ascorbic acid were compared to a control at the same pH stored under similar conditions. Three sample tubes were taken for spectrophotometric measurements after each storage interval, a portion of their contents being withdrawn by means of sterile disposable syringes. All data points represent the average of the three measurements. The percent pigment retention was calculated from absorbance measurements made before and after storage (A_{537}-after x 100/A_{537}-before).

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RESULTS & DISCUSSION

ISOASCORBIC ACID, an isomer of ascorbic acid also known as erythorbic acid, possesses antioxidant properties that can prevent deleterious changes in natural colorants (Esselen et al., 1945). This substance is generally recognized as safe when used in accordance with good manufacturing or feeding practice (CFR, 1979). Marked differences have been reported in the chemical, physical, and biological properties of the two ascorbic acid isomers (Kadin and Osadca, 1959). We compared isoascorbic and ascorbic acids as stabilizers of beet pigments in pH 5 solutions of beet juice powder stored in light and in darkness at 25°C and 5°C (Table 1). In all cases isoascorbic acid was a more effective additive than ascorbic acid. Samples with isoascorbic acid retained 52–65% of the pigment after 30 days of storage at 25°C, whereas the control sample faded to a yellow color within 6 days. In darkness at 5°C, the samples containing isoacorbic acid retained 95% of the red pig-

Table 1—Influence of additives on the stability of red beet pigment at pH 5[a]

Additive	Conditions	% of Pigment retention			
		5 Days	10 Days	20 Days	30 Days
None	Light/25°C	57	35	11	Cloudy
	Dark/25°C	67	50	25	Cloudy
	Dark/5°C	96	94	90	84
1.00% Isoascorbic acid	Light/25°C	75	60	50	39
	Dark/25°C	84	77	67	53
	Dark/5°C	96	95	93	91
0.50% Isoascorbic acid	Light/25°C	82	75	60	44
	Dark/25°C	88	82	71	58
	Dark/5°C	97	96	94	92
0.10% Isoascorbic acid	Light/25°C	85	80	66	52
	Dark/25°C	94	86	76	65
	Dark/5°C	100	99	97	95
0.01% Isoascorbic acid	Light/25°C	77	67	57	40
	Dark/25°C	85	76	65	52
	Dark/5°C	95	95	92	88
0.10% Ascorbic acid	Light/25°C	75	60	32	Cloudy
	Dark /25°C	84	72	50	Cloudy
	Dark/25°C	98	95	93	90

[a] Average of triplicate observations.

Table 2—Degradation rates[a] for aqueous solution of beet pigment as a function of pH and light at 25°C

Additive	pH	Light		Dark	
		$k(days)^{-1} \times 10^{-3}$	$T_{1/2}$ (days)	$k(days)^{-1} \times 10^{-3}$	$T_{1/2}$ (days)
0.1% Isoascorbic acid	3	43.6	15.8	21.8	31.8
	5	23.1	29.9	11.9	58.2
	7	30.5	22.6	23.8	29.1
0.1% Ascorbic acid	3	85.8	8.1	38.8	17.9
	5	52.5	13.2	33.7	20.6
	7	60.2	11.5	44.6	15.5
None	3	220.8	3.1	126.5	5.5
	5	110.4	6.3	69.3	10.0
	7	122.2	5.7	107.3	6.5

[a] Average of triplicate determinations

ment, as compared to 90% with ascorbic acid and 84% with control samples. A concentration of 0.1% isoascorbic acid was most effective in stabilizing beet pigments.

The effect of pH can be seen in Table 2. Samples were held at 25°C under constant light or in darkness with pH's adjusted to 3.0, 5.0 or 7.0. A semilogarithmic plot of percentage pigment retained vs days of storage yielded a linear relationship, which indicates that the degradation of betanine followed first order kinetics (von Elbe et al., 1974; Sapers and Hornstein, 1979). Values of the first order rate constant (k) and half-life ($T_{1/2}$) show that isoascorbic acid is more effective than ascorbic acid over the entire pH range studied in light as well as in darkness. The greatest pigment stability was obtained in samples adjusted to pH 5. The effect of pH on betanine degradation has been studied by von Elbe et al. (1974).

We also carried out similar testing at 50° and 75°C under artificial light, using a constant temperature bath (Blue M Microcontrol, Electric Co., Blue Island, IL). Here again, pigment degradation was less in samples with isoascorbic acid than in those containing ascorbic acid or in controls.

CONCLUSIONS

IT IS EVIDENT that isoascorbic acid provides protection against red beet pigment degradation, with the most effective concentration being 0.1%. The stabilizing effect was greatest at pH 5 in darkness; however, it improved stability under all storage conditions tested. Ascorbic acid also stabilizes beet pigments but the effect was smaller than that produced by isoascorbic acid. Further testing of isoascorbic acid as a stabilizer of natural pigments in foods and beverages will be carried out.

REFERENCES

Anonymous. 1978. Red 40 safety in doubt at HCI. Food Eng. 50(10): 35.

Bilyk, A. 1979. Extractive fractionation of betalaines. J. Food Sci. 44: 1249.

Code of Federal Regulations. 1979. Title 21, Chapter, I, Part 582.3041. Erythorbic acid.

Esselen, W.B. Jr., Powers, J.J., and Woodward, R. 1945. d-Isoascorbic acid as an antioxidant. Ind. and Eng. Chem. 37: 295.

Kadin, H. and Osadca, M. 1959. Biochemistry of erythorbic acid. Human blood levels and urinary excretion of ascorbic and erythorbic acids. J. Agric. Food Chem. 7: 358.

Muschiolic, G. and Schmadke, R. 1978. Zur Thermostabilität von Rote-Bete-Barbpulvern in Wässrigen Lösung. J. Nahrung 22: 637.

Pasch, J.H. and von Elbe, J.H. 1979. Betanine stability in buffered solutions containing organic acid, metal cations, antioxidants, or sequestrants. J. Food Sci. 44: 72.

Pasch, J.H., von Elbe, J.H., and Dinesen, N. 1975. Betalaines as natural food colorants. Food Prod. Dev. 9: 38.

Philip, V.M. 1978. How will we color soft drinks of the future? Food Prod. Dev. 12: 24.

Sapers, G.M., and Hornstien, J.S. 1979. Varietal differences in colorant properties and stability of red beet pigments. J. Food Sci. 44: 1245.

Savalainen, K. and Kuusi, T. 1978. The stability of golden beet and red beet pigments: Influence of pH, temperature and some stabilizers. Z. Lebensm. Unters.-Forsch. 166: 19.

von Elbe, J.H., Il-Yung Maing, and Amundson, C.H. 1974. Color stability of betanin. J. Food. Sci. 39: 334.

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